

METHOD AND APPARATUS FOR INTEGRATING A PALLET INTO A CONVEYOR SYSTEM

Field of the Invention

The present invention relates to a conveyor system, and more particularly, a method and apparatus for integrating a new or transferred pallet onto a conveyor of adjacently aligned end to end pallets.

Background of the Invention

Today's industrial assembly lines have become highly integrated and complex. For instance, the automotive industry now utilizes conveyor lines that carry individual automobile bodies on individual pallets called skillets. These skillets have large platforms that extend beyond the width and length of the automobile body so that automotive assemblers may stand on the skillets and assemble a portion of the automobile body while the skillets are moving with the conveyor line.

A tremendous amount of technology has been implemented into these skillets and their associated conveyor systems. For instance, lifts may be provided on the skillets to allow for the raising and lowering of the automobile body relative to the position of the assembler so as to provide the optimum ergonomic position for the assembler. In addition, the skillets may contain barcode information to provide the assembler information regarding the automotive body prior to or during the assembly of the automotive body.

Although such technology is responsible for a number of advancements with regard to

such assembly lines, problems still arise regarding the maneuverability of such skillets. Due to the size of the skillets and the fact that one main drive is typically utilized to drive the entire conveyor line of skillets by pushing the skillets end to end, it is difficult, if not impossible, to curve or bend the conveyor line. Therefore, the conveyor lines are typically straight. Since a conveyor line cannot continue straight throughout the entire assembly operation, the skillets must be transferred to different conveyor lines wherein they will again proceed along a substantially straight line. When transferring these skillets from one conveyor line to another, the skillets may be transferred underground or overhead. By transferring the skillets underground or overhead, valuable floor space is maximized in the plant.

When the skillets are transferred from a first conveyor line to a second conveyor line, the transferred skillets must be integrated onto the subsequent conveyor line such that the transferred skillet does not affect the flow of the skillets on the subsequent conveyor line. If while integrating the transferred skillet onto the subsequent conveyor line the transferred skillet bumps the last skillet on the conveyor line, a chain reaction may be created throughout the conveyor line, thereby causing the assembly line workers to lose their balance while standing on the skillets. In addition, the transferred skillet must become adjacently aligned with the last skillet prior to being driven by the main drive which drives the entire conveyor line. If this does not occur, a gap will occur between the transferred skillet and the last skillet thereby causing the two skillets to collide or bump at some point. In addition, integration of the transferred skillet must be done as fast as possible to maintain the efficiency of the assembly line.

Lastly, many conveyor lines have secondary conveyor lines that feed pallets,

workpieces, or parts to the primary conveyor line. Since these secondary conveyors must be synchronized with the primary conveyor, the speed of one conveyor cannot be adjusted without adjusting the speed of the other conveyor lines. This creates inefficiencies when changing the speed of the conveyors. Such inefficiencies are undesirable in an industrial environment.

It is desirable to provide a method and apparatus for integrating a new or transferred pallet onto a conveyor such that the new or transferred pallet does not bump the existing pallets in the assembly line. In addition, it is desirable to provide a method and apparatus for integrating a new or transferred pallet onto an existing conveyor line at a highly efficient rate. Lastly, it is desirable to provide a method and apparatus for integrating a new or transferred pallet onto an existing conveyor that allows for the adjustment of the speed of the conveyor lines while the conveyor lines are running.

Summary of the Invention

The present invention relates to a method and apparatus for integrating a new or transferred pallet onto a conveyor system. The apparatus provides a first conveyor for carrying a plurality of pallets end to end along a predetermined path of travel. A first motor is coupled to the first conveyor for driving the pallets at a first rate of speed. A first encoder is coupled to the first motor for monitoring the position of the last pallet on the first conveyor. A second conveyor is provided for introducing a new or transferred pallet to the first conveyor. A second motor is coupled to the second conveyor for driving the new or transferred pallet at a second rate of speed. A second encoder is coupled to the second motor for monitoring the position of the new pallet. A computer processor determines the relative

positions of the last pallet on the first conveyor relative to the new or transferred pallet on the second conveyor. The computer processor also determines the second rate of speed in order for the new or transferred pallet to become adjacently aligned with the last pallet within a predetermined docking area. A controller adjusts the second rate of speed of the second motor in response to a signal from the computer processor.

The method of the present invention includes providing and driving a plurality of end-to-end pallets at a first rate of speed. A new or transferred pallet is introduced at a position spaced from the adjacently aligned end-to-end pallets. The new pallet is driven at a second rate of speed. The position of the new pallet is monitored relative to the position of the last pallet. The second rate of speed is adjusted based on the relative position of the new pallet to the last pallet so that the new pallet eventually travels at the first rate of speed and becomes adjacently aligned with the last pallet within a predetermined docking area.

Brief Description of the Drawings

The description herein makes reference to the accompanying drawings wherein like reference numerals refer to like parts throughout several views, and wherein

Fig. 1 is a schematic diagram showing the first and second conveyor lines of the present invention.

Figs. 2a - 2f are schematic diagrams showing the sequential steps of the last and new skillets of the present invention.

Fig. 3 is a flow chart showing the steps of integrating a new skillet onto a conveyor of the present invention.

Description of the Preferred Embodiment

Referring to the drawings, the present invention will now be described in detail with reference to the disclosed embodiments.

Fig. 1 illustrates an apparatus **10** for integrating a new or transferred pallet or skillet **24** onto a first conveyor **14**. The conveyor **14** carries and directs a plurality of skillets **16** along a predetermined path of travel. The skillets **16, 24**, in turn, hold a workpiece **12**, such as a motor vehicle body. The skillets **16** are adjacently aligned end-to-end on the conveyor **14** wherein the entire conveyor line **14** of skillets **16** is driven by a main drive **20** at a first rate of speed. The main drive **20** drives a last skillet **16a** of the adjacently aligned skillets **16** on the conveyor **14** such that the last skillet **16a** pushes the remaining adjacently aligned skillets **16** along the predetermined path of travel.

To introduce the new or transferred skillets **24** to the first conveyor **14**, a lift or elevator **22** is utilized to lift the new skillet **24** from an underground conveyor or transportation system (not shown) which transfers the skillets **24** between adjacent conveyor lines (not shown). The lift **22** raises the new or transferred skillet **24** to the same level as the first conveyor **14**, and the new skillet **24** is moved onto a short second conveyor line **26** that carries and directs the new skillet **24** along a predetermined path that is coaxial with a longitudinal axis of the first conveyor **14**. A second motor or variable drive **28** drives the new skillet **24** along the second conveyor **26** at a second rate of speed. The second rate of speed is initially higher than the first rate of speed so that the new skillet **24** can advance toward the last skillet **16a** on the first conveyor **14** and become adjacently aligned with the last skillet **16a** within a predetermined docking area **30**.

In order to monitor the position of the last skillet **16a** on the first conveyor **14**, a first encoder **32** is coupled to the main drive **20**. The first encoder **32** counts the revolutions of the main drive **20**, thereby providing an indication of how far the main drive **20** has driven or pushed the adjacently aligned skillets **16**. When the last skillet **16a** on the first conveyor **14** passes a sensor **34** at the first rate of speed, as seen in Fig. 2a, the first encoder **32** is reset to zero. As the last skillet **16a** on the first conveyor **14** continues to travel at the first rate of speed, the last skillet **16a** passes a sensor **36** which is located at the start of the docking area **30**, as seen in Fig. 2b. When the last skillet **16** passes sensor **36**, the new or transferred skillet **24** is released onto the second conveyor **26** at position **37**. The last skillet **16a** continues to travel on the first conveyor **14** at a first rate of speed, and the first encoder **32** continues to track the position of the last skillet **16a** on the first conveyor **14**.

As the new skillet **24** travels along the second conveyor **26** at the second rate of speed, a second encoder **40** is reset to zero when the new skillet **24** reaches sensor **34**, as seen in Fig. 2c. The second encoder **40** is coupled to the main or variable drive **28** and monitors the position of the new skillet **24** by counting the rotations of the variable drive **28**.

To gradually align the new skillet **24** with the last skillet **16a** of the first conveyor **14**, a computer processor **42**, as seen in Fig. 1, analyzes the positions of the new skillet **24** and the last skillet **16a** to determine the second rate of speed necessary for the new skillet **24** to become adjacently aligned with the last skillet **16a** while both the new skillet **24** and the last skillet **16a** are within the docking area **30**. Once the new skillet **24** engages sensor **34**, as seen in Fig. 2d, the computer processor **42** calculates a deceleration ramp through the following equation:

$$\text{RAMP} = ((\text{SECOND RATE OF SPEED}) - (\text{FIRST RATE OF SPEED})) / ((\text{POSITION OF THE LAST SKILLET}) - (\text{POSITION OF THE NEW SKILLET}))$$

Once the deceleration ramp is calculated, the speed of the new skillet **24** is continuously calculated through the following equation:

$$\text{SPEED OF NEW SKILLET} = (\text{RAMP} ((\text{POSITION OF THE LAST SKILLET}) - (\text{POSITION OF THE NEW SKILLET})) + \text{SPEED OF THE LAST SKILLET})$$

The computer processor **42** sends a signal to a controller **44**, as seen in Fig. 1, indicating the desired speed for the new or transferred skillet **24**. The controller **44** is coupled to and adjusts the variable drive **28** to correspond with the desired speed of the new or transferred skillet **24** as determined by the computer processor **42**. Therefore, as the distance between the new or transferred skillet **24** and the last skillet **16a** gets smaller, the speed of the new or transferred skillet **24** approaches the speed of the last skillet **16a**, until the new skillet **24** and the last skillet **16a** touch, as seen in Fig. 2e. When the skillets **16a**, **24** touch or become adjacently aligned, the position of the last skillet **16a** and the position of the new skillet **24** will equal zero, thereby leaving the speed of the last skillet **16a**, the first rate of speed, to equal the speed of the new skillet **24**, the second rate of speed. By providing constant updates as to the speed of the new skillet **24** by the computer processor **42**, the speed of the first conveyor **14** can be changed to any rate and may be changed at any time during the production and running of the first conveyor **14**. Once the new skillet **24** passes sensor **34**, the new skillet **24** is considered integrated onto the first conveyor **14**, and the new skillet **24** then becomes the last skillet **16a**.

In order to integrate and adjacently align the new skillet **24** with the last skillet **16a** of the first conveyor **14** within the docking area **30**, the new skillet **24** maintains a predetermined upper level of the second rate of speed until the new skillet **24** reaches the start of the docking area **30**. The docking area **30** is the shortest deceleration distance possible for the application based on the mechanical capabilities of the associated motors and gear boxes of the variable drive **28**. Therefore, deceleration of the new skillet **24** does not begin until the new skillet **24** reaches the docking area **30**. This is monitored by the computer processor **42** making the following calculations:

If (POSITION OF LAST SKILLET - POSITION OF NEW SKILLET) is greater than the minimum docking distance **30**;

then (SPEED OF THE NEW SKILLET) = (UPPER LEVEL OF THE SECOND RATE OF SPEED);

otherwise, (SPEED OF THE NEW SKILLET) = (RAMP x (POSITION OF THE LAST SKILLET - POSITION OF NEW SKILLET) + SPEED OF THE LAST SKILLET)

To prevent a gap from being created between the last skillet **16a** and the new skillet **24**, the new skillet **24** is integrated into the first conveyor **14** and will stop if it does not immediately engage a sensor **46** located at the end of the docking area **30**. When the new skillet reaches sensor **46**, as seen in Fig. 2f, the new skillet **24** should be adjacently aligned with the last skillet **16a**, and therefore, sensor **46** should be continuously actuated by the skillets **16a, 24**. If sensor **46** is not actuated by the new skillet **24**, the new skillet **24** is stopped so as to prevent the ramming or bumping of new skillet **24** into the last skillet **16a**. A backup system is provided in a sensor **48** which is located further downstream the first

conveyor 14 from sensor 46. If sensor 48 becomes exposed, a fault is generated and indicated to the user that the new skillet 24 is not properly aligned with the last skillet 16a.

Fig. 3 shows the steps of integrating the new skillet 24 onto the first conveyor 14. In operation, the first conveyor 14 of skillets 16 progresses forward at the first rate of speed, as seen in block 50, as assemblers assemble the workpieces 12 on the skillets 16. The last skillet 16a passes sensor 34 and resets the first encoder 32, as seen in block 52. The new skillet 24 is introduced to the first conveyor 14 through the lift 22. When the last skillet 16a reaches sensor 36, the new skillet 24 is released from position 37, as stated in block 54. The new skillet 24 moves along the second conveyor 26 at the highest second rate of speed possible or at a predetermined upper level of the second rate of speed. When the new skillet 24 reaches sensor 34, the second encoder 40 is reset to zero, as stated in block 56. As the new skillet 24 continues to travel and reach the beginning of the docking area 30, the computer processor 42 begins to calculate the second rate of speed of the new skillet 24 required for the new skillet 24 to become adjacently aligned with the last skillet 16a within the docking area 30. As seen in decision block 58, the computer processor 42 first determines whether the last skillet 16a and the new skillet 24 are within the docking area 30. This is determined by subtracting the position of the last skillet 16a from the position of the new skillet 24. If the difference is greater than the docking area 30, then the computer processor 42 continues to monitor the position of the skillets 16a, 24 until the skillets 16a, 24 are within the docking area 30. Once the skillets 16a, 24 are within the docking area 30, then the ramp can be calculated, as seen in block 60. The computer processor 42 utilizes the relative positions of the last skillet 16a and the new skillet 24 along with the first rate of speed of the last skillet 16a to determine the

deceleration of the second rate of speed of the new skillet 24, as seen in block 62. The computer processor 42 provides a signal to the controller 14 which adjusts the variable drive 20 of the second conveyor 26, as seen in block 64. The speed of the new skillet 24 is continually reduced until the new skillet 24 becomes adjacently aligned with the last skillet 16a whereby the new skillet 24 will assume the same rate of speed as the last skillet 16a, as seen in block 66. The new skillet 24 is then integrated into the first conveyor 14, and the process is repeated by having yet another new skillet introduced onto the second conveyor 26, as seen in block 68.

While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to those disclosed embodiments, but on the contrary, it is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims which scope is intended to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures as is permitted under the law.